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December 10, 1868.

Dr. WILLIAM ALLEN MILLER, Treasurer and Vice-President,
in the Chair.

It was announced from the Chair that the President had appointed the following Members of Council to be Vice-Presidents:—

The Treasurer.

Dr. Carpenter.

Mr. Gassiot.

Mr. Prestwich.

Capt. Richards.

Pursuant to notice given at the last Meeting, General Sabine proposed and Sir Roderick Murchison seconded the Right Honourable Lord Houghton for election and immediate ballot.

The ballot having been taken, Lord Houghton was declared duly elected.

The following communications were read:—

- I. "On the Phenomena of Light, Heat, and Sound accompanying the fall of Meteorites." By W. RITTER v. HAIDINGER, For. Mem. R.S. &c. Received October 6, 1868.

A particular incident caused me to return to some portions of my earlier studies in regard to meteors and meteorites.

It was the fall of a meteorite at Kakowa on the 19th of May 1858 that first induced me to bestow some more attention on this department of physical science. A report on the subject I laid before our Imperial Academy of Vienna on the 7th of January, 1859. On the same day also I gave the first list of the meteorites forming the meteorite collection in our Imperial Mineralogical Museum. A series of reports on meteorites followed, as well as a number of catalogues of meteorites, in accordance with the growing riches of the collection, embracing from 137 to 236 numbers of localities preserved up to the date of July 1, 1867.

But the studies relating to the recent fall of Aussen on the 9th of December 1858, and the ancient fall of the meteoric iron of Hraschina, near Agram, on the 26th of May 1751, others on the Cape meteorites of 1838, on those of Shalka, 1850, Allahabad, 1822, Quenggouk (Pegu), 1857, Assam, found 1846, Segowlee, 1853, St. Denis-Westrem, 1855, Nebraska, found 1856, but particularly some studies relating to meteorites of Stannern, 1858, and of that most remarkable meteoric iron from Tula, discovered in 1856 by Auerbach, all of them within the period of 1851 to 1860, and then the fall of New Concord, 1860, and of Parnallee, 1857, had forcibly called upon me to draw up, as it were, a general rule of the nature and succession of events which probably might have taken place in the history of their existence, though in each particular case only fragments of that history came to our notice.

A general survey of this kind I had the honour to lay before our Imperial Academy on the 14th of March 1861, "On the nature of Meteorites, relating to their composition and the phenomena of their fall"* . I felt, it is true, that I had rather too boldly ventured to transgress the limits of my former studies ; but at the same time, led on by the high interest connected with the subject, I wished to gain some more publicity for it. As to England, I was most kindly and effectively patronized by that energetic promoter of meteoritic science my most honoured friend Mr. R. P. Greg. He laid a notice of mine before the British Association for the Advancement of Science, held that year at Manchester, and accompanied it with several considerations of his own† ; then, also, he kindly had the pages of the *Philosophical Magazine* opened for me, and presented me with an edition of separate copies of a memoir on the subject—nearly a translation, by my honoured friend Count A. F. Marschall, of my original communication to our Academy‡.

At the Meeting of German naturalists and physicians at Speyer, my honoured friend Dr. Otto Buchner kindly called the attention of the friends of this department of natural science to my memoir, which had been favourably mentioned in the reports.

A note of mine, containing the leading views of my papers, was likewise laid by my honoured friend M. Elie de Beaumont before the Paris Académie des Sciences in their Meeting of September 9th, 1861, while I also sent a French translation by my excellent friend Count Marschall, together with a copy of my original memoir§.

Since that time, up to this day, I had frequently, in several communications on meteoritic subjects, had an opportunity to refer to these leading papers, and to support the views which they contained. Therefore I had every reason to be astonished when I read, in a recent work on meteorites by M. Stanislas Meunier||, the following assertion :—" We may observe that a great number of particular phenomena occurring in the fall of meteorites have hitherto remained without explanation. Thus the reason of the ex-

* "Ueber die Natur der Meteoriten in ihrer Zusammensetzung und Erscheinung," Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften, der Mathem.-naturw. Classe, 1861, Band xliii. Abth. ii. S. 389-425.

† "An attempt to account for the Physical Condition and the Fall of Meteorites upon our Planet, by W. Haidinger, Hon. Memb. R.S.L. & E. &c.," Report, 1861, Transactions of the Sections, p. 15. "Some Considerations on M. Haidinger's Communication on the Origin and Fall of Aërolites, by R. P. Greg, F.G.S.," *ibid.* p. 13.

‡ Considerations on the Phenomena attending the Fall of Meteorites on the Earth, by W. Haidinger, For. Memb. R.S.L. & E. ; and *Philosophical Magazine* for November and December 1861.

§ "De la nature des bolides et de leur mode de formation. Lettre de M. Haidinger," *Comptes Rendus hebdomadaires des séances de l'Académie des Sciences etc.* t. liii. Juillet-Décembre 1861, pp. 456-461.

|| *Étude, descriptive, théorique, et expérimentale sur les Météorites*, par M. Stanislas Meunier. Paris, 1857, p. 18.

plosions, and particularly of the repeated explosions, that of the rumblings, that of the incandescence, are still absolutely unknown”*.

But I had still more reason to be astonished when I found M. Daubrée himself nearly upon the same level in his views respecting the origin of light, heat, and sound in the fall of meteorites.

I certainly heartily appreciate the high merit of my honoured friend M. Daubrée, in regard both to his deep studies on meteorites and his eminent success in forwarding the interests of the Paris Museum of Meteorites; but I at the same time may be permitted to consider my own views, as given in the memoirs quoted, as representing a scientific advance compared with the statements of M. Meunier and those of M. Daubrée himself in his last memoir on the Orgueil fall†. Neither M. Daubrée nor M. Meunier had refuted or even objected to my views; they had only passed them over in silence, doubtless because they had escaped their notice.

But I believe I am fulfilling a duty to scientific progress if I endeavour to place the discrepant and even contradictory views on these subjects together, with the view once more to excite attention and recommend them to further study on the part of the votaries of natural science; and it was with this view that I prepared a new memoir, to be laid before our Imperial Academy in their approaching period of session, on the light, heat, and sound accompanying the fall of meteorites. I begin with some of the statements put forth by M. Daubrée, as taken from his memoir on Orgueil:—

“Things go on as if the greater part of the mass of the meteor got out of our atmosphere, in order to continue its course, after having left us some particles, the velocity of which, in consequence of the explosion, was reduced”‡. M. Daubrée does not admit the arrival of groups or swarms of meteorites as has been asserted§. “The carbonaceous meteorites contradict the hypothesis that the heat of the meteorites is due to the loss of their *vis viva*”||. The sounds, detonations under the name of explosions, remain without explanation¶.

M. Daubrée attributes to mere chance the situation of what he calls “scales,” or “*écailles de météorites*,” at the moment of an explosion, if they present certain particular seams of crust surrounding their most ex-

* “Remarquons qu’un grand nombre de particularités offertes par la chute des météorites sont restées jusqu’à présent sans explication. Ainsi, la cause des explosions et surtout des explosions multiples, celle des roulements, celle de l’incandescence, sont absolument inconnues.”

† “Complément d’Observations sur la chute de météorites qui a eu lieu le 14 Mai 1864 aux environs d’Orgueil,” *Nouvelles Archives du Muséum d’Histoire Naturelle*, t. iii. pp. 1–19.

‡ “Les choses se passent donc comme si la plus grande partie de la masse météorique ressortait de l’atmosphère pour continuer sa trajectoire, n’abandonnant que quelques parcelles dont la vitesse, à la suite de l’explosion, se trouvait amortie.”—*Op. cit.* p. 15.

§ Comme on l’a dit.

|| “Les météorites charbonneuses contredisent l’hypothèse que la chaleur des météorites est due à la perte de leur force vive.”—*Op. cit.* p. 8.

¶ “Sans explication.”—*Op. cit.* p. 16.

tended surface, by which, being foremost, they forced their way through the opposing atmosphere. In regard to this position I had long ago advanced that it must have been a necessary result, while the rectilinear movement of the meteorite was in the way of being checked, of part of the force having been expended in producing a rotatory motion, perpendicular to the direction of the course. This I did in particular, in a paper on the meteoric iron of Hraschina, on the 14th of April 1859, then on an aërolite from Stannern on the 22nd of May 1862, and in other instances.

The above-mentioned quotations of M. Daubrée's views are now compared with the successive periods of progress in the fall of meteorites, nearly in the same words as I proposed them in 1861.

In the arrival of meteorites on our earth:—

1. Single or agglomerated fragments, in their cosmical course, come into contact with our globe.

2. The fragments are arrested by the resistance of atmospheric air.

3. Pressure, in their progress through the atmospheric air, elicits light and heat; rotation ensues, and a melted crust is formed.

4. The white-hot compressed air is spread out in the form of a fireball, closed up behind, and enclosing the fragment, or fragments, and a vacuum-space.

5. The cosmic course is at an end when the fragment, or the fragments, have been arrested by air.

6. Light and heat are no longer generated; the vacuum-ball will collapse with a loud report, or several reports following each other.

7. The cosmic cold within the aërolite assists in reducing the heat of the melted crust.

8. The meteorite falls down upon the earth like any other ponderous body, the hotter the better conducting material it consists of.

In this way I believe it was my duty again to lay before the public the differences of the views newly taken by M. Daubrée from those which I hitherto had advocated.

But while I was engaged in contrasting them I found myself conspicuously supported by a number of recent publications relative to the subject in question. In one of his own papers M. Daubrée had to register the statement of M. Leymerie, of Toulouse, who considered the fall of Orgueil as presenting not one meteoric mass exploded, but a swarm of aërolites arrived at the same moment.

But above all, two reports of the fall of 30th January 1868, near Pultusk, both of them kindly presented to me by their respective authors, bore ample testimony in favour of a number of my theses, and enlarged them by deeper and more accurate investigation beyond what I formerly proposed.

These are the memoir "On the Course of the Pultusk Meteorite"*, by

* Ueber die Bahn des am 30. Januar 1868 beobachteten und bei Pultusk im Königreiche Polen als Steinregen niedergefallenen Meteors durch die Atmosphäre. Vom Professor Dr. C. G. Galle, Direktor der Sternwarte zu Breslau. Vorgetragen am 4.

Professor J. G. Galle in Breslau, and another, "On the Meteorites of Pultusk" *, by Professor G. vom Rath, in Bonn.

In both of them the most evident proofs are given of the actuality of a swarm, consisting of a very great number of distinct aërolites, having entered our atmosphere.

The course of the Pultusk meteor, according to M. Galle, met the horizontal line under an angle of 44 degrees at the place of dispersion, at a height of 25·25 English miles, or $5\frac{1}{2}$ German miles. After its movement was checked, and the force of it expended in the development of light and heat, how would it have been possible that, as it would follow from M. Daubrée's supposition, the great mass of the meteor should have risen again and left our atmosphere to continue its cosmical orbit? Nor could such be the case with the Knyahinya meteor, which pounced upon our earth almost from the zenith of the place, the course making an angle only of 6 degrees with the perpendicular. But even the Orgueil meteor moved in a direction meeting the horizontal line at the point of dispersion under an angle of about $11^{\circ} 26'$, from which position it certainly could not rise again higher up into the atmosphere, and still less leave it altogether.

I availed myself of the circumstance that I had been gratified by several honoured friends with a number of important publications closely connected with the subject, to quote some appropriate passages. I would refer especially to that grand 'Atlas of Charts of Meteor-tracks,' by Messrs. R. P. Greg and A. S. Herschel †, together with the "Reports of Luminous Meteors for the years 1865 and 1866-1867" ‡, and to the recent memoir by M. G. V. Schiaparelli on the astronomical theory of falling stars §, kindly sent to me by the late lamented Matteucci. Schiaparelli holds forth that in shooting-stars "the *vis viva*, while the meteoric matter is dispersed in the atmosphere, is completely destroyed by being transformed into heat and light" ||. From

März u. s. w. Besonderer Abdruck aus den Abhandlungen der Schlesischen Gesellschaft für vaterländische Cultur. Breslau, 1868.

* Ueber die Meteoriten von Pultusk im Königreiche Polen gefallen am 30. Januar 1868. Von Dr. G. vom Rath. Mit einer Tafel. Besonders abgedruckt aus der Festschrift der Niederrheinischen Gesellschaft für Natur- und Heilkunde zum 50jährigen Jubiläum der Universität Bonn.

† Atlas of Charts of the Meteor-tracks contained in the British Association Catalogue of Observations of Luminous Meteors, extending over the years from 1845 to 1866, &c. Prepared for the Luminous-Meteors Committee of the British Association by R. P. Greg and A. S. Herschel.

‡ Report on Observations of Luminous Meteors, 1865-66, by a Committee consisting of James Glaisher, F.R.S., of the Royal Observatory, Greenwich, Secretary to the British Meteorological Society; Robert P. Greg, F.G.S.; E. W. Brayley, F.R.S.; and Alexander Herschel, B.A. From the Report of the British Association for the Advancement of Science for 1866. The same for 1866-1867.

§ 'Note e riflessioni intorno alla teoria astronomica delle Stelle Cadenti.' From the work 'Memorie di Matematica e di Fisica della Società Italiana delle Scienze fondata da Anton Mario Lorgna,' ser. 3, tomo i. parte 1. p. 153, Firenze, 1867.

|| "Questa forza viva, dileguandosi la materia meteorica nell' atmosfera, viene completamente distrutta trasformandosi in calore ed in luce."—*Op. cit.* p. 198.

Mr. A. S. Herschel's observations with the spectroscope, we learn that the condition of the August meteors is exactly that of a flame of gas in a Bunsen's burner freely charged with the vapour of burning sodium, or of the flame of a spirit-lamp newly trimmed and largely dosed with a supply of moistened salt (*op. cit.* p. 146). The idea of a diminutive fireball containing the solid mass, although diminutive itself, surrounded by a luminous gaseous case, including a vacuum, till the force of the movement is spent in heat and light, may not be considered inadequate to the subject.

In a most interesting memoir entitled "Contributions to the Knowledge of Falling Stars"*, by Dr. Edmond Weiss, of Vienna, that able astronomer (the representative, together with Dr. Oppolzer and Lieut. Reziha, of the Austrian Navy, of our Austrian expedition for the eclipse of 18th of August at Aden, where they were so hospitably welcomed and kindly supported by the Governor-General, J. Russell, in behalf of the British Government, along with the North-German expedition, composed of Drs. Vogel, Fritsche, Zenker, and Thiele) considers among other subjects the influence of the earth's attraction upon shower-meteors, independently of Schiaparelli's disquisitions relative to the same subject, and points out also the circumstance that some of them may receive such a direction as to leave our solar system altogether, while Dr. Galle insists upon the fact that the Pultusk swarm must have entered it with an independent force of at least from $4\frac{1}{2}$ to 7 English miles (1 to $1\frac{1}{2}$ geographical miles).

My original design was only to offer some appropriate remarks on the subject of the phenomena of light, heat, and sound generated in and accompanying the arrival of meteorites on the earth through our terrestrial atmosphere; but the different departments of natural science referring to meteors and meteorites are of so manifold a nature, that I frequently was obliged to advert to some of them in regard to which I should rather have kept more on the reserve. But the whole range of meteor- and meteorite-science, continually enlarging, more and more clearly presents itself in these four grand sections:—1st, the original formation of meteorites; 2nd, their movement through cosmic space; 3rd, their arrival through the atmosphere upon our earth; and, 4th, the studies instituted on the objects themselves, which fall into our hands and are preserved in our museums. To the third of these sections it is that my particular attention was directed.

* "Beiträge zur Kenntniss der Sternschnuppen, von dem c. M. Dr. Edmund Weiss. Vorgelegt in der Sitzung am 16. Jänner 1868," Sitzungsberichte der Math.-nat. Classe der Kais. Akademie der Wissenschaften, lvii. Band ii. Abth. 5. pp. 281-342.